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Inside

Fire-Wise Construction

From the Editor

I've noted that, increasingly, interior designers seem to be quite aware of environmental and indoor air quality issues. More and more product manufacturers are describing the source of the raw materials for their products, their manufacturing processes, and their products' emissions. "Green" issues are getting attention.

Perhaps this has been driven by the fact that interior designers are more likely to be involved in commercial projects, where employee productivity is important and indoor air quality concerns have been heightened after the realization that the "sick building syndrome" is real. Maintaining a healthy indoor environment is less expensive than dealing with sick employees.

While we need a healthy indoors, it is also important to realize that the global environment must remain healthy. That is why resource efficiency and energy efficiency are equally important and go together. That means making the best use of materials and paying attention to the resources we use.

When I am in the market for any product I consider its source and try to select a product with the least negative impact on the environment. With that in mind, I was astounded recently when I had to purchase new window blinds. My vertical fabric blinds had reached the end of their useful life and had to be replaced. I took a sample fabric vane to a number of dealers to get quotes. That is where a surprise awaited me. The prices I was given for replacement vanes alone – in other words, for just the fabric portions – were significantly more expensive than the price of buying a whole new system, including the track and all associated hardware.

It was not a case of the blind being an odd size, since there is no such thing as an off-the-shelf vertical blind; they are all custom-made. It was not a case of the blind being small, since the window is large and it would be a substantial order in any event. Unlike venetian blinds that are available off the shelf in a few standard sizes, vertical fabric blinds are only available on custom order. So a custom order of just the fabric elements should not be more expensive than a package unit that is customized with a lot of extra hardware. However, to get a fair deal, buyers have to get the whole package.

My issue here is that the original hardware is fully functional and does not need to be replaced. Forcing people to purchase the hardware just creates excess production and all the waste associated with it, from manufacturing and packaging, to shipping, to the disposal of otherwise functional materials.

When you need to replace the tires on your truck, you don't replace the whole truck. When your saw blade wears out or a drill bit gets dull, you don't replace the equipment, but just the worn-out part. Yet in the window blind industry, replacing just the worn-out parts seems to be impossible to do. And the industry is getting away with it.

I was beginning to hope that the players in our industry were finally coming to grips with environmental issues. Now I wonder how many other similar conditions exist. We really need to find a way to minimize the excess waste we produce. The earth just can't support so much waste.

Richard Kadulski,
Editor

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Fire-Wise Construction

The forest is no longer the dark and mysterious place as pictured in so many children's tales. Today it is considered to be a prime residential location, close to the conveniences of the urban environment, yet not quite in the city. We appreciate that the trees keep the air clean and provide welcoming shade in the summer. We enjoy the forest, and increasingly we try to live at the edge of if not in the forest itself.

The destruction by forest fires of hundreds of homes in Kelowna last year highlighted the implications of living in what is known as the forest interface region. The Kelowna fire was not unique. Similar destructive events are seen every year around the world wherever people live on the edge of forests.

Although people are responsible for about half the forest fires, these are a natural phenomenon. They've always happened, and will continue to happen. They are one way that nature uses to manage the forest ecology. In fact, some plant species require a fire before they can regenerate themselves.

Forest management practices in recent years have stressed protection of the merchantable timber often ahead of sustainable forest ecology. The intent was to minimize loss of timber and to reduce the smoke associated with intentional brush clearing fires or accidental fires. As a result, the amount of fuel in the forests has increased. When this is combined with the effects of climate change brought on by human activity, it creates conditions where more spectacular fires can spread quickly.

Communities have expanded into the forest zone. Many suburban developments have been built with little if any analysis of the impact of the development in the forest interface zone. In many cases the design and planning guidelines have contributed to making the situation worse by insisting on the use of inappropriate building designs, materials, and landscaping.

Although some communities have well-defined forest edges, others, especially smaller towns, are entirely within the forest. Forestry and fire prevention personnel shudder at the type of development in places such as Whistler, which are entirely within the vulnerable forest interface zone.

Homes within forested areas are often beyond the community fire department's operating limits. Some developments lack provisions for fire protection or roads suitable for the movement of fire fighting equipment.

The Building Code and planning guidelines are generally developed from an urban point of view. In the city densities are higher, properties are fully serviced and fire issues tend to focus on the prevention of fire spread between buildings. Because of the availability of emergency services, there is less concern about the exterior design and materials. Ironically, it was fire safety issues that let to the development of building codes in the first place.

Anyone living or building on the edge of a forest must prepare for the risk of a wildfire. A home's chances of survival can be greatly improved through careful design, site layout and maintenance. Simple, cost effective and attractive fire-safe alternatives should be considered when building or renovating a home. This means selecting appropriate materials and detailing to minimize the fire risk, perhaps by choosing less combustible materials than originally planned.

As a result of the fire property loss in 2003, BC is now promoting fire-smart home design. The program is based on work that has been done in the southwestern United States and more recently in Alberta. Information for homeowners and builders has been assembled in publications that have been posted on the Internet.

We present a summary of points to consider when planning construction in the forest interface zone.

Site Design

Building a fire-wise home in the forest may require some compromises with the quality of the treed environment that encourages people to move into the forest in the first place. Surround the home with defensible space since vegetation is fuel for a forest fire. Trees and brush around the house should be thinned and pruned within the first 10 feet of the house. Dead or highly flammable trees should be removed first. A wider open space may be appropriate.

Generally, a fire moving up a slope moves faster and has longer flames than one on level ground because hot gases rise in front of it, preheating its path. The rate of fire spread doubles for every 20% increase in the slope, so it is best to build on the most level portion of a site and thin downslope trees. If the property is sloped, structures should be kept at least 30 feet back from any ridge or cliff, more if the house is more than one storey.

Cantilevered wood decks on a hillside could be in direct line of a fire moving up the slope and should be avoided. Consider terraced patios instead.

Decks become hazardous when combustible materials and debris accumulate underneath them. Firewood or cured needles and grasses stored or built up under decks are a serious threat to any house. Enclosing the underside of decks and porches with non-combustible screening or siding material, and keeping the space completely free of combustible material reduces the chances of an ignition source finding its way under.

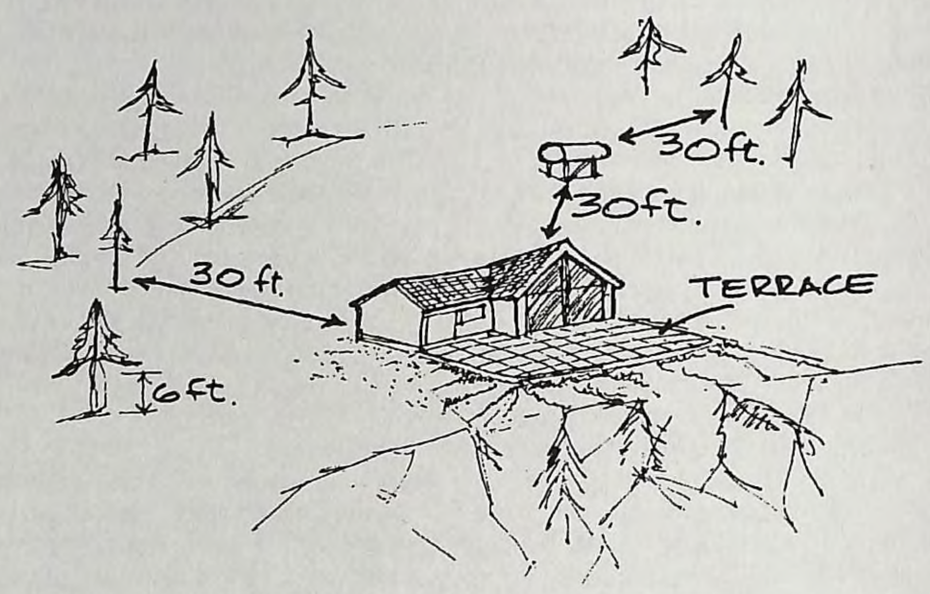
Wood fences are flammable. If they are attached to the house, they act like fuel bridges, leading a fire right to the house.

Landscaping

There are two primary principles in designing landscapes to protect against fire: fuel reduction and interruption of fire path. A fire-safe landscape uses fire-resistant plants that are strategically planted to resist the spread of fire. A fire-safe landscape need not be expensive, and will also conserve water.

Remember that fire does not respect property lines, so the whole community needs to be involved.

While all plants will eventually burn, healthy plants will be harder to ignite. Drip irrigation systems are effective and conserve water because they target where the water goes and how much gets there. Use sprinklers for lawns and ensure your lawn is getting the right amount of water to keep it green, healthy and fire resistant.



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Fire Wise Design/Construction

Roofs

A major cause of home loss in forest fires is the flammability of roofing materials. Roofs can catch fire easily when wind-blown sparks land on them or from direct contact with flames from nearby trees, shrubs or neighbouring structures.

Fire retardant treatments are only effective for a period of time. Treated wood shakes should be considered untreated after five years unless they are further treated. More resistant roofing products include asphalt shingles, metal, clay and concrete tiles. A fire resistant sub-roof can add protection as well.

Steeper roof pitches are safer than a flat roof, as embers are more likely to roll off them.

You can't depend on exterior roof sprinklers to protect flammable roofs from burning. Not only is water pressure at its lowest during a fire, but there may not be any electricity needed to pump the water, and the winds associated with a wildfire can divert the spray from the roof.

Siding Materials

Siding materials are almost as vulnerable to fire as the roof. Non-combustible siding materials such as traditional cement stucco, metal, brick, cement shingles, concrete block and stone veneer are best for forest homes. Wood siding is susceptible to ignition from radiant heat. Vinyl will soften and melt.

Balconies, Decks and Eaves

Overhanging construction traps heat and embers and will increase the risk of structure loss, especially if it is over a hill or cliff. Where decks need to be built, enclose the under side of overhangs with non-flammable material or plywood sheathing

Construct balcony and deck surfaces of non-combustible or fire retardant materials. Deck supports should be non-combustible materials. Heavy timbers are more fire resistant.

Windows and Vents

Regular plate glass often breaks due to rapid changes in temperature or bombardment by wind blown projectiles. Double pane windows are somewhat better than single panes and smaller panes hold up better in their frames than larger ones. Skylights can also be a potential entry point for fire. Plastic skylights can melt under intense heat and flying embers.

One way to protect the home in the event of a wildfire is to cover windows and skylights with non-flammable screening and fire shutters.

Windows should not face trees or brush within 10 metres (30 feet).

Electric Utilities

Maintain a three metre (10-foot) clearance between branches and power lines. Clear combustible material within three metres (10 feet) of propane and natural gas tanks. Locate tanks at least 10 metres (30 feet) away from the structure.

Chimneys

Chimneys should be covered with a wire screen - mesh no larger than 12 millimetres (1/2 inch). Tree branches should be cleared within three metres (10 feet).

Maintenance

All efforts at fire-safe design and construction are in vain without maintenance.

Homeowners need to be informed that ongoing maintenance is needed to clear and remove dead wood and dense vegetation from at least 10 m (30 ft) from the house, and to keep firewood away from the house.

Roofs and gutters should be cleaned on a regular basis. ☼

Moisture Movement through Concrete Foundations

Recent items about rising damp (Solplan Review No. 113, November 2003) and a follow-up question about foundation design details (Solplan Review No. 115, March 2004) prompted Kevin North of Vancouver Humidity Control Systems to reply.

His comments raise a number of interesting points. They underline the point that moisture problems are best avoided by proper water management when the foundation is built. Proper construction and moisture management from the outset is always the best and least costly solution to construction. This is his slightly edited commentary.

The experiment measuring the moisture wicked through the concrete might have produced more pertinent results if a hair dryer had been added to the top of the concrete column sitting in the bucket of water. The addition of heat or "conditioned" air to the concrete column would have dramatically increased the drying effect or evaporative rate of moisture from the column.

The capillary absorption of water by a porous solid depends not only on the properties of the water but more particularly on the micro structure of the solid. The ability for concrete to adsorb and wick moisture is determined by the pore size and the interconnectedness of the "stices" in the concrete.

While you are correct in stating "foundations and basements can be a major source of moisture as groundwater is sucked up into the house" and "the industry has not examined the impact of water wicking in concrete" here are some key factors that influence this phenomenon:

1. Water to cement ratio

A key determinant in concrete strength and durability is the water to cement ratio. The porosity of the concrete used in construction in BC is clearly determined by this ratio. Permeability increases exponentially when concrete has a water to cement ratio of more than 50%. When water is added to provide workability or when water is added on the job site because of sloppy handling procedures or even worked during rainy weather, the result is the displacement of the cement paste that binds the aggregates together to form a tight "watertight" mix.

Although it is known that increasing the water to cement ratio decreases the compressive strength of the concrete, it is less well known that porosity rises dramatically. Hydration and the displacement of the cement paste by the bleed water leave microscopic fractures and stices for the moisture to exploit when the concrete hardens.

2. Thermal Cycling

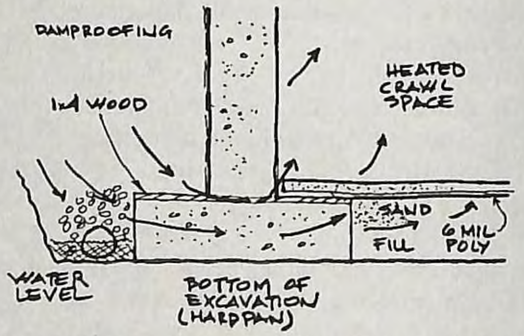
Duff and Hall, authors of *Water Transport in Brick and Stone*[1] write, "For heterogeneous materials changes of temperature will cause thermal stresses to develop as a result of differences in the thermal expansivity of different regions or components of the material. Such stresses might be concentrated in concrete at the aggregate and cement paste interface (and) will promote crack propagation with a consequent increase in porosity." According to the authors, "it cannot be assumed that porosity is unaffected by heat in any material subject to thermal dehydration or decomposition. This is particularly true of materials containing chemically bounded water such as cement. . . . Thermal cycling can produce progressive dehydration accompanied by micro-structural changes and progressive changes in the porosity."[2]

In short, the effect of heating cycles on the inside of unprotected concrete surfaces may be to increase the porosity of foundation walls. Combine this with our affinity to place heating ducts (and registers) in these underground concrete bunkers and we are seeing an exponential rise in moisture related issues in this area.

When we apply hot dry air to unprotected concrete surfaces, we are increasing the evaporative and wicking potential of that material.

3. Crawl Spaces

Since we have been installing hot air ducts in poorly constructed crawl spaces for some years now, we have been aiding moisture and evaporation rates.



Example of conventional construction practice with moisture problems. Arrows are direction of moisture movement.

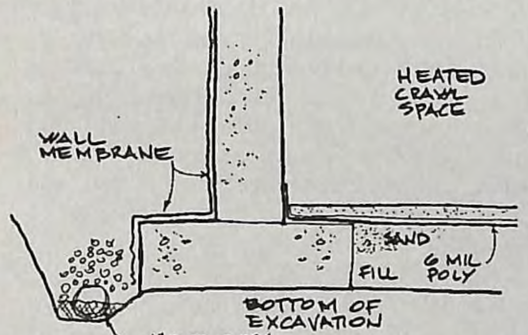
In combination with the general trend to use unfinished concrete in the mechanical room, comes the idea to consider the crawlspace as a mini basement and not to ventilate it to the outside. Although I agree that outside air is not the best solution, it does not make sense to me to allow the air handler to suck up this moisture and distribute to the rest of the house, especially when the crawl space is known to be contaminated with bio-aerosols, dust mites, construction materials, insect debris, moulds and rodent excrement!

Clearly, keeping the crawl space air from entering the rest of the house or at least not polluting the rest of the house will help maintain good indoor air quality in the house.

My last point is that while pore size and saturated conditions can combine to provide the action of "rising damp," moisture can and will also "hydraulically conduct" in an unrestricted flow process.

The conditions for moisture flow and vapour entry are not a readily understood concept by many contractors. The "damp proofing" industry is doing a dubious job at best. Applying a bituminous coating to green or hydrating concrete after it has barely left the forms is a questionable proposition at best, even though it satisfies Building Code requirements.

There is also the common practice of building the foundation wall and footing in a "mono" pour. Typically, 1"x 4" wood cleats are left inside, ready to rot and provide water entry ports to the granular material located under the slab. This is also a ludicrous practice.



Better construction detail. Moisture membrane on wall must lap over footing, and perimeter drain tile must be sloped and at the lowest level of the excavation

4. Footing Drains

It makes no sense to protect the top portion of the foundation wall with a waterproofing membrane wall if the membrane just deflects water to an unresponsive and non-functioning footing drain.

Footing drains catch deflected ground water and then transfer that load to the path of least resistance, which too often is the excavated ground adjacent to or near the concrete footing. Wall membranes merely accelerate the rate at which water reaches the footing drain, and if the footing drain is not able to carry the water away fast enough we are just adding more water to a bad situation.

In my opinion, footing drains must have a gradient to carry water away from the footings. Installations of less than 2% are really problematic. In addition, the highest invert of the footing drain must be placed below the bottom elevation of the footing to provide any relief from ground water and the load sent to it by the membrane and granular fill.

Providing flat drainage beds to wick water away from porous concrete surfaces seems like a whimsical idea at best. In seventeen years of uncovering and investigating pipe failures we know that flat or minimum grade installations lead to low flow conditions that create ponding and pools of water near or at our foundations.

In conclusion, the most sensitive area of wall assemblies according to senior researcher M. Lacasse of NRC is the area where the building envelope stays "too wet for too long."[3]

I wonder when the Building Code will address the chronic problem of sub-surface drainage conditions here in BC? When poor footing details and poor concrete practices combine have we just waited "too patiently for too long" where ground moisture and wicking is concerned?

If the rain in Spain falls mainly on the plain . . here in BC, it stays at the footing!

In my opinion, one of the most common latent defects we have in new home construction today is the uncontrolled wicking of ground water into crawl spaces caused by the combination of poorly constructed footing drains, unprotected footing walls, an insatiable supply of ground water outside and an incongruous supply of hot dry air from the air handling system inside. ☼

Notes:
[1] *Water Transport in Brick and Stone, Christopher Hall and William D. Hoff, Spoon Press, New York, 2002*
[2] *Duff and Hall, p. 20-22*
[3] *Solplan Review No. 113, November 2003*

Insulating Concrete Form Construction

Insulating concrete form (ICF) walls for use in residential construction is gaining market share. ICF systems are promoted as superior to conventional wood-frame construction because of their energy efficiency and ease of construction. However, like their wood-frame counterparts, ICF walls also require attention to detail so moisture problems can be avoided.

Moisture problems in wood frame construction include condensation, peeling paint, mould and mildew. These can be the result of high indoor relative humidity, poorly designed heating, cooling and ventilation equipment, or poorly designed or built building envelope details. One common location for moisture entry is at window joints, which can cause rotting of wood-frame construction.

Concrete entails large quantities of water immediately after placement of the concrete, so the question that comes up is: What happens to the water in the concrete in ICF walls, since not all the water is used in the hydration process? Normally this moisture escapes after construction as the concrete dries. However, building materials such as the polystyrene insulation, vapour retarders, and exterior finishes such as EIFS are relatively impermeable to water vapour transmission. These materials may trap water vapour within the wall, or may slow the water vapour transmission so that moisture-sensitive materials such as wood and drywall may become wet for long periods of time. Although concrete is not damaged by moisture, wood and drywall are easily damaged.

A study by the Portland Cement Association was done to try to determine the potential for moisture problems in ICF walls due to moisture from construction, water vapour transmission, improper placement of a vapour retarder, and window framing and flashing details.

Six typical ICF walls were built and monitored in a laboratory for one year to determine their drying rates. The nominal ambient conditions inside the room were 23°C (73°F) and 50% RH.

Each wall each had different insulation, exterior finishes, and interior finishes. Three were exterior insulated finish systems (EIFS), two had hardboard lap siding, and one Portland cement stucco. A commercially available, pumpable 3,000 psi (21 MPa) concrete mix was used in the wall sections. The concrete had a slump of 6½ in. (165 mm), and an air content of 7%.

Three walls had poly vapour barriers; three relied on painted drywall.

Drying Results

After the test period, the walls were cut open and the materials were visually examined for moisture-related damage such as mould, mildew, corrosion, rot and fungi attack. The visual inspection revealed that none of the building materials from any of the walls suffered from moisture damage.

At the end the one-year period, the concrete, polystyrene, drywall, and exterior finishes performed adequately and did not show any signs of moisture-related problems. The moisture content of the various materials in the ICF walls at the end of the one-year period was found to be similar to the equilibrium moisture content that was to be expected.

Minor surface corrosion was observed on portions of drywall screws removed from the walls. The corrosion was limited to the portion of the screw that penetrated the polystyrene insulation. It was not possible to determine when the corrosion started, or if it may be a long-term concern. However, the interior finishes were installed within three to seven days after the concrete was placed in the ICF. This was done intentionally to trap moisture in the wall and is not typical of actual construction practices.

A dew point analysis indicated that a vapour retarder is recommended between the drywall (interior finish) and insulation only in cold climates. Cold weather climates are defined as locations with more than about 3900 heating degree days (°C). This means that most parts of Canada, with the exception of southern BC and the extreme south of Ontario should have a vapour retarder.

Another analysis showed that there is a potential for freeze-thaw damage to hardened concrete in ICF walls when outdoor temperatures fall below -26°C (-15°F). As a result, air entrained concrete is recommended for ICF walls in locations with winter design temperatures are less than -26°C (-15°F). ✪

*The complete report, **Moisture in Insulating Concrete Form Walls**, by John Gajda, and Martha G. VanGeem, PCA R&D Serial No. 2190a is available through the Portland Cement Association.*

Window Installation in ICF Walls

Installing windows in ICF walls can present a challenge. Typical window details applicable to all types of ICF systems have been developed by the Portland Cement Association and are available in PCA Research Bulletin 2190, ***Moisture in ICF Walls***. In developing the details, consideration was given to making them cost effective and easily buildable.

The window details use a treated wood buck that spans the full thickness of the ICF walls. All bucks are positively anchored into the concrete with galvanized screws which are fastened to the rough buck before the buck is placed in the ICFs.

Galvanized anchors are required because moisture from the concrete will quickly corrode non-galvanized anchors. Rough bucks should be constructed using high quality pressure-treated lumber. Untreated wood, in direct contact with concrete, will rot and decay.

The details show how water should be diverted out of the wall below the window by using a self-adhesive membrane as a secondary flashing beneath the window. In this way, any water that does get behind the cladding will be deflected outward, rather than move further into the wall assembly.

The preferred window detail is one where the windows are recessed because many moisture-related problems are attributed to flush-mounted windows. Flush-mount windows are subject to as much precipitation as the exterior finish, while recessed windows are somewhat protected. Recessed windows are easy to achieve, since ICF walls are thicker, so a smaller block can be used to create a step. (Fig. 3)

Flush-mounted windows have joints between dissimilar materials at the exterior surface of buildings. Protection of these joints from precipitation will reduce the degradation of sealants and moisture-susceptible materials.

All joints and gaps greater than 3mm must be sealed with foam or a caulking against a back rod.

Figure 1 shows a typical head flashing end dam and head flashing and sealant details common to all of the details. The end dams on window head flashing are common to the flush-mounted windows presented, and are used to channel any water penetrating the exterior finish out of the wall.

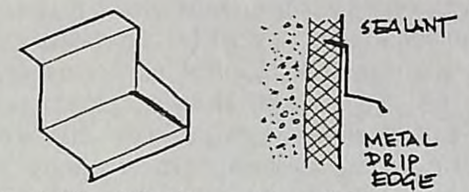


Fig 1. Head flashing with end dam; flashing sealant connection to ICF.

The sealant detail illustrates the proper method of applying sealant to joints. This detail is provided because proper installation of sealant is important, and it is often not properly installed. A hot wire cut into the foam allows the flashing to be slipped in, and a mastic, sealant, or expanding foam compatible with the ICF materials is applied to seal in the flashing. ✪

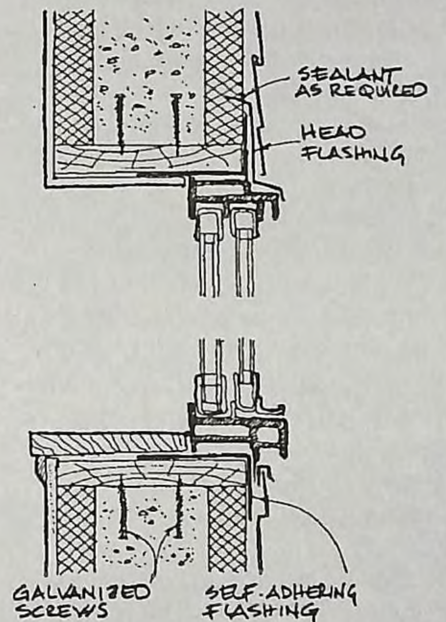


Figure 2. ICF wall with a typical flush-mount (surface mount) flanged vinyl window and vinyl siding. Because wood can hold significant amounts of moisture, if wood and cement board lap siding is used, it should be applied over 1x furring to maintain a separation from the polystyrene by an air space.

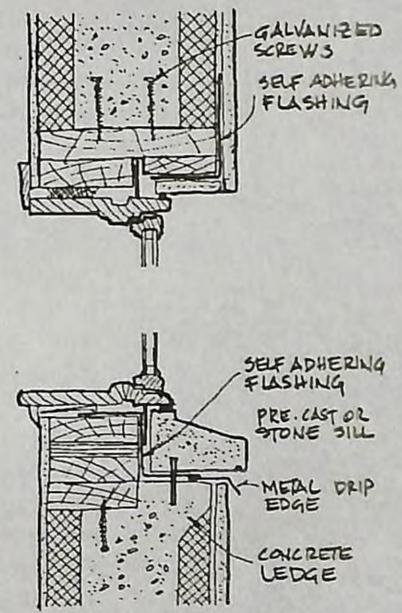
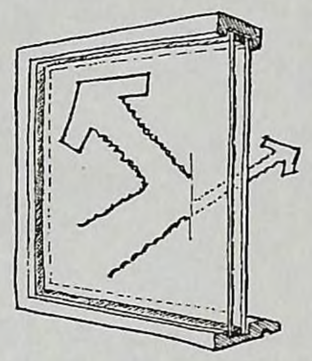


Figure 3. ICF wall with a recessed wood window and stucco cladding.

Window Properties and Terminology



Light and view are two of the fundamental functions of a window. Advances in glass technology in recent years have made glass a significant aesthetic element in modern architecture and without as big an energy penalty as in the past. We now see glass towers everywhere. New high- rise developments in Vancouver are designed with a glass aesthetic in mind. Canadian author Douglas Coupland calls Vancouver a "city of glass."

Windows give us views, fresh air and light. They are also the source of significant heat losses and unwanted solar heat gains. Windows can account for 35% to 50% of the total heat loss of a modern house. The large glass areas in many new houses also have a direct impact on home comfort conditions.

Changes in glass technology mean that there are also many changes to the properties of glass itself.

In heating-dominated climates with a modest amount of cooling (which describes all regions of Canada), high performance windows with new glazing technologies not only reduce energy costs but also make homes more comfortable. The best windows perform almost as well as a fully insulated 2x4 frame wall.

Selecting windows is very different than selecting framing materials, bricks, or roofing materials – products that have been in use for a long time, are well understood, and have relatively few variables affecting their performance. The many variables associated with windows means that anyone selecting or purchasing a window must consider a number of issues beyond the type of frame and opening mechanism.

Proper window selection requires paying attention to a number of technical properties. Unfortunately, most window marketing is still done on the basis of window frame profile, material finish and operating hardware appearance and performance. Even window salespeople themselves are not familiar with all the technical issues and downplay them. They rarely ask purchasers the questions they should. When was the last time you were asked about the orientation of the windows? Do you want to keep the heat in or out? Will there be overhangs on the windows?

For information on the R-2000 Program, contact your local program office, or call 1-800-387-2000 www.R-2000.ca

Today's glass technology means making a more detailed window selection. It is appropriate to consider different glass options for different orientations. There is no single best option for all cases. For instance, if the house has large west-facing windows, it will be subject to overheating in the summer no matter what kinds of overhangs are installed because of low afternoon sun. Only if there is a solid hedge or cliff near the house on that side will overheating be avoided. For such windows, heat rejection glass should be considered. Windows that keep the heat in should always be selected for north-facing windows in the northern hemisphere.

South-facing windows can have a properly-sized overhang to prevent overheating in summer but allow low winter sun into the house. Carefully selected glazing can maximize passive solar gains into the house, contributing valuable heat.

So what is the best type of window? It really depends. An understanding of window properties is required, as well as where the windows are to be installed. We present some essential terms to consider here, to help builders and designers understand what they mean. It is worth noting that different terms can be used to describe essentially the same properties. Some terms commonly used in the US are different from those used in Canada. With the increased market share for US companies in the Canadian market, there is a drive to harmonize standards, so we will be seeing more US terminology to further confuse the issue.

Energy Star. A voluntary marketing program that identifies high performance windows. Performance criteria vary with climate conditions. Canadian and US criteria vary, although all rely on the same calculation methods.

Energy Ratings (ER). This is a measure of a window's overall energy performance. It is a calculated value and takes into consideration solar heat gains and heat loss through frames and air leakage. The ER value can be either a positive or negative number depending on heat gain or loss. A positive number means that, on average, the window will have a net energy gain, while a negative number means the window represents a net heat loss. The formula for ER calculation is part of the CSA A440.2 standard.

Gas fill. A gas other than air, usually argon or krypton, placed between window or skylight glazing panes to reduce the U-value (improve the insulating value) by suppressing conduction and convection.

Low-conductance spacers. Materials designed to reduce heat transfer at the edge of an insulating window. Spacers are placed between the panes of glass in a double- or triple-glazed window.

Low-emittance (low-E) coating. Microscopically thin, virtually invisible, metal layers on a window surface primarily to improve the window's insulating value. A typical low-E coating is transparent to the solar spectrum (visible light and short-wave infrared radiation) and reflective of long-wave infrared radiation.

Emittance is expressed as a ratio of from 0 to 1. The lower the number, the lower the emittance. The lowest emittance window coatings have a value of 0.04. A wood stove painted black is a near perfect emitter of heat and will have an emittance approaching 1.

Hard coat low-E. A low emissivity surface that is applied during the glass manufacturing process, and typically has an emissivity of about 0.2. These coatings can also be applied to single-glazed glass panes.

Soft coat or sputtered are low emissivity coatings applied on the surface of finished glass. Soft coats are vulnerable to oxidation, so they must always be inside sealed glazing units. These coatings can have emissivity values as low as 0.04.

R-value. A measure of the resistance of a glazing material to heat flow. It is the inverse of the U-value (R = 1/U) and is expressed in units of hr-sq ft-°F/Btu. A high-R-value window has more resistance to heat flow and a higher insulating value than one with a low R-value.

Shading coefficient (SC). A measure of the ability of a window to transmit solar heat compared to that of 1/8-inch clear, single glass. It is expressed as a number without units between 0 and 1. SC is being phased out in favour of the solar heat gain coefficient, and is approximately equal to the SHGC multiplied by 1.15. The lower a window's SC, the less solar heat it transmits.

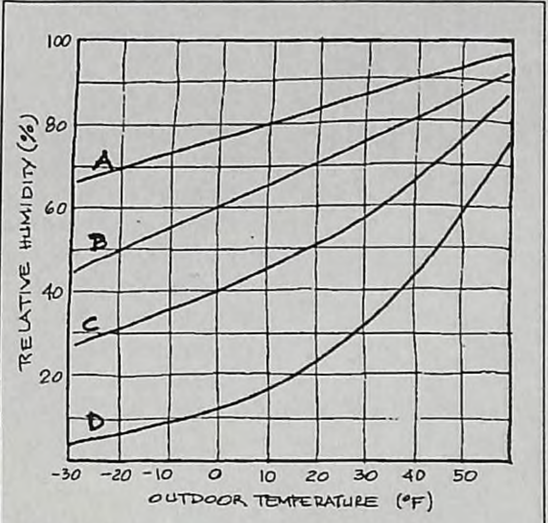
Solar heat gain coefficient (SHGC) is a measure of how well a window keeps the heat out. It is the fraction of solar radiation entering through a window. The solar heat gain coefficient is the standard indicator of a window's shading ability. SHGC is expressed as a number between 0 and 1. The lower a window's solar heat gain coefficient, the less solar heat it transmits. SHGC can be expressed in terms of the glass alone or can refer to the entire window assembly.

In heating climates, a high SHGC increases passive solar heating gain. You want a window with a low SHGC where you want to keep heat out.

Spectrally selective coating. A coated or tinted glass with optical properties which are transparent to only some wavelengths and reflective to others. Typical spectrally selective coatings are transparent to visible light and reflect short-wave and long-wave infrared radiation.

U-value (U-factor). A measure of how well a window keeps the heat in. It is expressed in units of Btu/hr-sq ft-°F (W/sq m-°C). Values are normally given for standard winter conditions of 0° F (18° C) outside, 70° F (21° C) inside, 15 mph wind, and no solar load. The U-factor may be expressed for the glass alone or for the entire window, which includes the effect of the frame and the spacer materials.

The U-value is the inverse of the R-value. A window with an R-value of 2 has a U-value of 0.5. The lower the U-factor,



The condensation potential on the glass (centre of glass area at least 2 ½" from the frame/glass edge) at various outdoor temperature and indoor relative humidity conditions.

A - Triple glazed, 2 low-e coatings, argon fill
B - Double glazed, low-e, argon gas
C - Double glazed, clear glass
D - Single glazing

Condensation can happen at any point that falls on or above the curves. As the insulating value of the windows improves (U-value decreases), there is a much smaller range of conditions where condensation will occur.

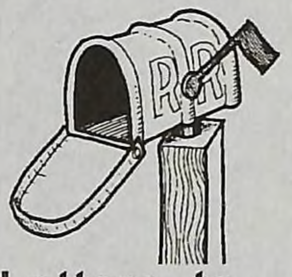
Graph: from Efficient Windows Collaborative web site, a project supported by the U.S. Department of Energy's Windows and Glazings Program and the industry. *www.efficientwindows.org*

the higher a window's resistance to heat flow, and the better its insulating value. The best windows to retain heat will have the lowest U values.

Ultraviolet light (UV). The invisible rays of the spectrum that are outside the visible spectrum at its short-wavelength violet end. Ultraviolet rays are found in everyday sunlight and can cause fading of paint finishes, carpets, and fabrics. Laminated glass blocks out UV rays, which is why you will never get a tan sitting behind the windows of your car.

Visible light. The portion of the electromagnetic spectrum that produces light that can be seen. Wavelengths range from 380 to 720 nanometres.

Visible transmittance (VT). The percentage or fraction of the visible spectrum (380 to 720 nanometres) weighted by the sensitivity of the eye, that is transmitted through the glazing. ☼



Letters to the Editor

Re: Wood Publications (TRC News, Solplan Review No. 116, May 2004)

You have done both us and your readers a disservice by improperly identifying one of our publications. I refer to the reference to the fact sheet Discolourations on Wood Products: Causes and Implications in your May 2004 issue. The publication is a Forintek publication (not the Canadian Wood Council), prepared in association with the UBC School of Occupational and Environmental Hygiene. It is available on the Forintek web site (*www.forintek.ca*), and on the web site we run jointly with CWC (*www.durable-wood.com*). It can not be found at *www.cwc.ca,* as the article states.

Our durability web site *www.durable-wood.com,* contains a wealth of information of potential interest to your readership.

Jennifer O'Connor
Forintek Canada Corp.

Oops! We stand corrected.

This gives us the chance to add that Forintek produces fact sheets on key topics related to the wood products industry and of interest to wood users. Forintek has produced the following publications in collaboration with various partners:

* *Borate-Treated Wood for Construction*
* *Moisture and Durability*
* *Combatting Termites*
* *Discolourations on Wood Products*
* *Earthquake-Resistant Housing*
* *Fire Safety*
* *Wood-frame Construction, Fire Resistance and Sound Transmission*
* *Sustainable Design and Wood*
* *Protecting and Finishing Log Buildings*

Also available is a Wood Protection Bulletin: Properties of lumber with beetle-transmitted bluestain.

Copies of these fact sheets are available on the Forintek web site. For more information, or for hard copies of the fact sheets, contact the Forintek Publication Services at one of the following locations:

Western Division
Publications@van.forintek.ca
Tel: 604-224-3221 Fax : 604-222-5690
Eastern Division
Publications@qc.forintek.ca
Tel: 418-659-2647 Fax : 418-659-2922

Re: Zero Energy Houses (Solplan Review No. 116, May 2004)

I just read the article on zero energy houses and wondered if you were aware of the Envirohome 2000 house built by Steve Crowell of Crowell Construction in the Annapolis Valley two or three years ago? It is quite a remarkable project since it was built for a private individual without much outside funding and with a fairly small incremental price tag.

Brian L Hayes
Halifax, NS

You are right to point out that there are other examples. In fact, we published a note about the house at the time.

I suspect that there are many other houses throughout the country that either are or approach zero energy or autonomous house criteria. Many are built privately without much fanfare and are not in any registry. Most are not rocket ships or hippy hovels, but blend into the neighbourhood. Steve Crowell's project shows that it is possible to build very efficient homes with small if any incremental costs. If individuals can build such efficient homes, why is it so difficult for market housing to approach those performance levels? Ed.

Technical Research Committee News

Canadian Home Builders' Association

Membership Benefits: Reducing Red Tape in Winnipeg

The benefits of an association are its power to negotiate on behalf of a larger group of builders.

The Manitoba Home Builder's Association and the City of Winnipeg have discussed a separate door policy for obtaining building permits.

Once received by the City, plans and engineered drawings will receive professional service and a turnaround time of 5 days. The City has also agreed that engineered drawings which include an undertaking from a professional engineer to review the structural design and assembly will be exempt from plan examination prior to permit issuance.

This service is available to MHBA members only.

Fire Performance of Housing Elements

Fire protection is one of the basics behind building codes and regulations. Much information is available about the performance of specific materials in a fire. Some construction assemblies are tested and have ULC ratings, which are published in ULC directories. Most of these are for materials and assemblies used in larger commercial, institutional and multi-family residential buildings built under Part 3 of the Building Code. These directories set out the fire performance of assemblies. However, most of these assemblies are not used in single family construction.

Conventional construction assemblies used in residential construction have evolved over the years and predate the era of extensive testing. As a result, there is no benchmark against which testing agencies and building officials can evaluate the fire performance of new and innovative systems. Nor does Part 9 of the Building Code set fire resistance standards for most commonly used construction assemblies.

New products and systems are continually being proposed for use in housing. Because there is no protocol by which these new products and systems can be evaluated, the Institute for Research in Construction is looking at developing standard evaluation procedures by which an assessment can be done for new products.

Unlike commercial construction, residential construction has many assemblies that are left open and unprotected on one side. For example, the structure for the main floor over an unfinished basement is usually left exposed and will perform differently during a fire than a floor structure with a finished ceiling on the underside.

A concern for the housing industry is that the concept of benchmarking traditional construction and developing new evaluation procedures don't represent a way to introduce new standards that would render long-established construction practices unacceptable. CHBA will be maintaining contact with IRC on this initiative.

Performance of Exhaust-Only Ventilation Systems

We know that houses must have adequate ventilation and building codes require it. However, the design of a ventilation system, and its installation and effectiveness is another issue altogether.

Because of the desirability of having effective ventilation systems that are affordable and easy to implement, BC and Ontario introduced their own modified prescriptive code requirements in the 1990s. These essentially allow exhaust-only ventilation systems relying on a slightly better quality principal exhaust fan.

We can install code-compliant ventilation systems, but do they actually work?

CMHC conducted a small study to see whether homeowners knew what type of ventilation systems they had and whether they were using them properly. Three out of four of the 120 houses that were looked at had ventilation systems that relied on a bathroom exhaust fan with a switch as the control for the ventilation system.

Ninety percent of the people who had such a system did not know how to properly operate it. Although the systems were installed correctly and were code compliant, many of the homes

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.

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had moisture or indoor air quality concerns.

The study shows that people generally don't understand how their ventilation system works. They don't understand that a simple system may be a combination of fans. Because they don't understand the system, in practice it is not effective.

This study once more reinforces the point that key systems in a home must be simple to operate. Ideally they will be "transparent," so that the operating system is out of sight and out of mind to the occupant. A system that does not create any noise or discomfort is less likely to be tinkered with or shut off by the home-owner. ☼

Energy Answers

Rob Dumont

What is the relationship between insulation and the amount of heat loss? People tell me that there are diminishing returns from adding "too much" insulation.

Let me begin by stating that I am a great believer in insulation. The house I live in has an R80 attic, R60 walls, R60 basement walls, and R35 basement floor. Overall, it has about two to three times the amount of insulation of conventional new homes in the Saskatchewan climate. The extra insulation works for me almost every hour of the year, has no moving parts to wear out and, protected by proper rain and vapour barriers, should last the life of the building.

That said, it is true that there are diminishing returns as you add more and more insulation. The first amount of insulation you add does more good than subsequent amounts. The following graph shows the heat loss in Btu per hour from an insulated attic in Saskatoon, where the outside design temperature is -30°F (-34°C). The table presents the heat loss as a function of the amount of insulation for a temperature difference of 100°F across the insulation.

Heat Loss as a function of Insulation

R-value (hr-ft²°F/BTU)	Heat Loss (BTU/hr-ft²)
10	10.0
20	5.0
30	3.3
40	2.5
50	2.0
60	1.7
70	1.4
80	1.3

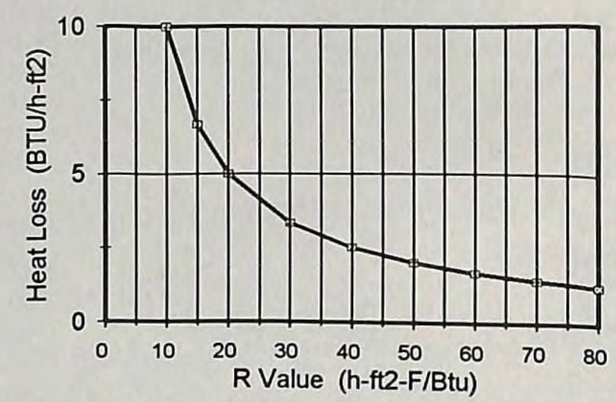

Figure 1. Heat loss as related to R Value (Temperature Difference is 100 °F)

At an R-value of 10, the heat loss is 10 Btu/hr per square foot. If the insulation level is doubled to R20, the heat loss drops to 5 Btu/hr per square foot; with R30 the heat loss falls in half again to 3.3 Btu/hr per square foot. Going to R80 decreases the heat loss to 1.3 Btu per hour per square foot.

Another way of looking at it, going from R10 to R40 saves 7.5 Btu/hr per square foot. Adding an additional R30, i.e., increasing the insulation level from R40 to R70, saves only 1.1 Btu/hr per square foot. This is obviously lower than the 7.5 Btu/hr per square foot of heat loss saved by increasing the insulation level from R10 to R40.

Many people look at Figure 1 and say that the knee in the curve occurs when the R value reaches about 40. Going beyond R40 is not "cost-effective." I contend that this is a wrong conclusion.

Why do I say that?

Here's my reasoning. If you plot the same heat loss relationship using different vertical and horizontal axes, you get a relationship shown in Figure 2. If you look at that graph, and apply the same logic used with Figure 1, the knee in the curve shows up at about R80 or so.

How you plot the data often slants the conclusion that you want people to draw.

The correct amount of insulation that you put in a building depends on a large number of factors. In general, the colder the climate and the more expensive the cost of heating, the more insulation you can justify. If you use a more expensive type of insulation (rigid polystyrene instead of glass fibre batt, for instance), you can only justify smaller amounts of insulation.

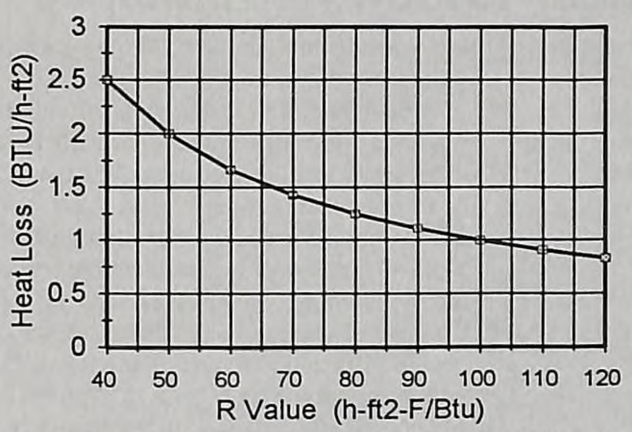

Figure 2. Same data as in figure 1 but with different x and y axes.

Can you save money on a heating system by using more insulation?

Definitely.

Let me use an example from my own experience. My family and I recently built a new cabin in the shadow of the Rocky Mountains in B.C., half way between Fernie and Cranbrook. We want to be able to use the place year round, and some family members may eventually live there year round. For heating the cabin, we had several alternatives: natural gas, electricity, oil, and propane. I estimate that a quality forced-air furnace installation using natural gas would have cost about $6000. Instead we opted for electric baseboard heaters with an installed cost of about $1000, and then used the $5000 savings on the heating system to increase the insulation in the building.

We used R20 rigid insulation in the floor slab, R36 in a double-stud exterior wall and R50 attic insulation. The $5000 savings on the heating system just about paid for the extra insulation. A bonus is that the electric baseboard heating uses a renewable resource in B.C. A second bonus is that the electric baseboards have almost zero maintenance compared with a furnace. A third bonus was that we did not have to upgrade the electrical service for the house – a 100 amp panel was enough to supply the house and the baseboard heating.

To summarize, investment in insulation can reduce the size and cost of the heating system in a building. The standard economic analysis for quantity of insulation that is found in most textbooks and in the ASHRAE handbooks ignores this vital fact. ☼

NRC-CNRC

Improved Spacer Bar Design Enhances Window Performance

by A.H. Elmahdy

Heat loss through the insulating glass (IG) units of windows can cause condensation leading to mould growth and deterioration of windows and wall sections, especially in cold climates. The high thermal conductivity of conventional aluminum or steel spacer bars used to separate the panes in an IG unit results in relatively high heat loss through the bars and the surrounding area of the window (known as the edge-of-glass region). This increases the potential for condensation. The edge-of-glass region extends about 60 mm (2.3") from the edge of the frame or sash to the point where the glass surface temperature is the same as that of the center of the glass.

IG units with warmer surface temperatures in the edge-of-glass region are less likely to see condensation. The temperature in this region depends on a number of factors including spacer bar design and frame material. The overall thermal performance of a window will be determined by the type of spacer bar, the glazing and the frame (for fixed windows) or sash (for operable windows). Thus, although a window with a high temperature in the edge-of-glass area will perform well in terms of condensation resistance, it may not necessarily show good overall thermal performance.

The use of spacer bars with lower thermal conductivity than conventional metal spacer bars in the edge-of-glass region is known as Warm-Edge Technology (WET). WET spacer bars have either a thermal break in the spacer assembly or are made of materials with low thermal conductivity. WET reduces the heat flow from the warm side to the cold side of the glazing, thus reducing condensation. This is especially true of high-performance IG units with low-emissivity coatings on the glass and using an inert gas, such as argon or krypton, as an insulator in the sealed cavity.

A number of innovative spacer bars have been developed in the past decade. In order to evaluate the thermal performance of these new spacer bars, NRC's Institute for Research in Construction (IRC) conducted a study. The study assessed the performance of ten different types of spacer bars (nine WET and one conventional) in IG units without window frames (unmounted) and with window frames (mounted) of various materials.

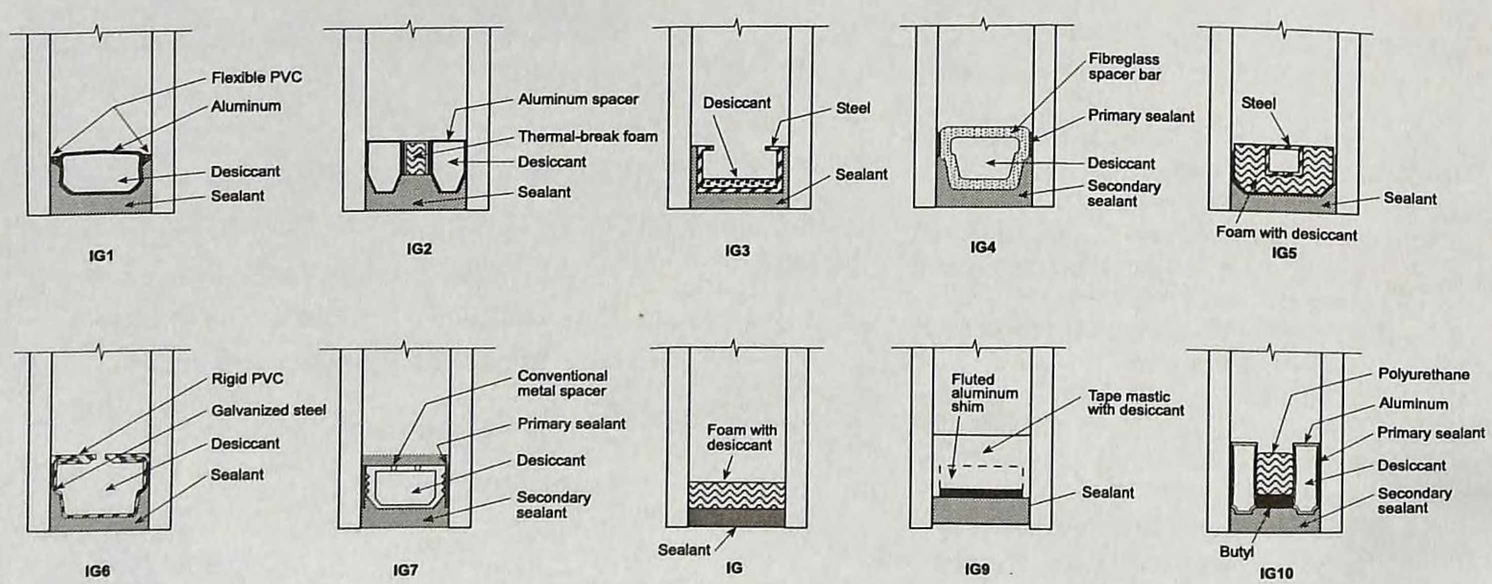

Figure 1. Spacer bar assemblies IG1 to IG10

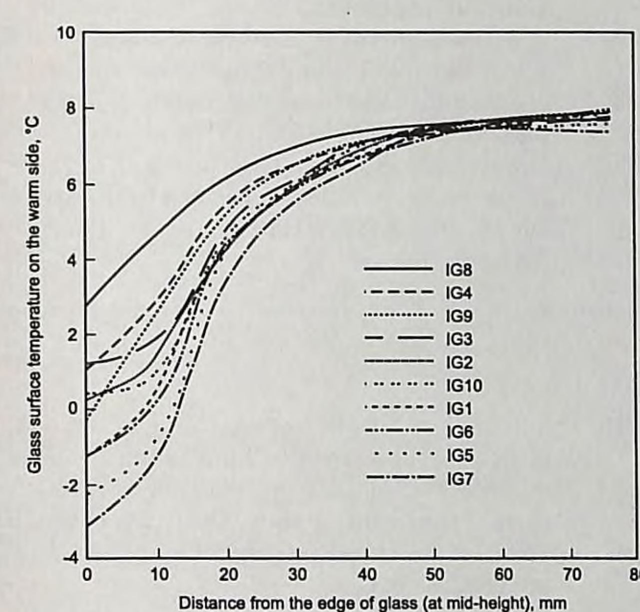

Figure 2. Warm-side glass surface temperatures for IG units

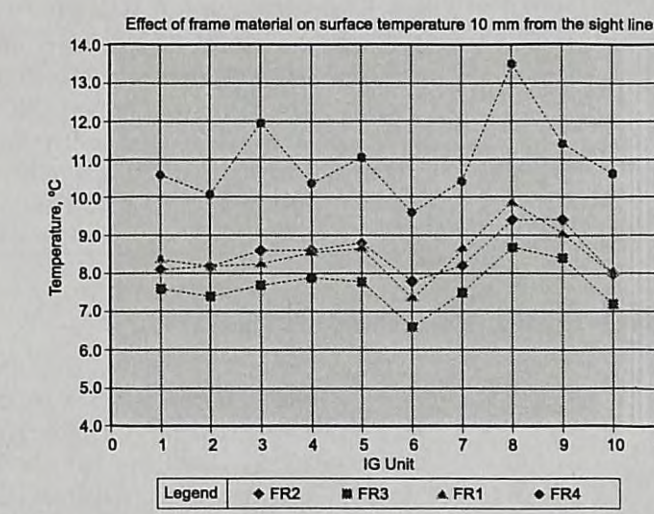

Figure 3. Effect of frame material on glass surface temperature 10 mm from sight line

IG Units without Window Frames

Ten IG units, made by different manufacturers (Figure 1), were tested for heat loss by measuring their surface temperatures at the mid-height of the glass. All units were 152 mm x 1200 mm (6"x 48"), air-filled and made of clear glass.

Figure 2 shows the warm-side glass surface temperatures for the ten IG units without frames, when exposed to a temperature difference of 38°C [20°C on the warm side and -18°C on the cold side]. Unit IG8 had the highest glass surface temperature at the edge-of-glass region, making it the best in terms of reducing condensation. IG7 had the lowest glass surface temperature in the edge-of-glass region. Although the temperature difference between the best- and poorest-performing IG units was only about 6o C in the edge-of-glass region, it could have a considerable effect on condensation resistance. Figure 2 also shows that the glass surface temperatures on all ten IG units, away from the edge-of-glass region were similar.

IG Units Installed in Window Frames

The IG units with ten different spacer bar configurations were then tested as part of a complete fixed window assembly. Temperatures were measured at different horizontal planes on the warm side of the window. Four different types of frame specimen, FR1 (redwood), FR2 (vinyl), FR3 (thermally broken aluminum) and FR4 (foam-filled fibreglass), were also used, to determine whether the type of frame had any influence on the spacer bar performance.

Figure 3 shows the effect of WET spacer bars on the temperature measured at 10 mm from the sight line, for each type of IG unit and frame specimen, when exposed to a temperature difference of 38°C. The combination of FR4 and highly insulated spacer bar IG8 offered the warmest glass-surface temperature at the 10-mm plane (and at almost all the horizontal planes in the edge-of-glass region). Conversely, the combination of FR3 and hybrid spacer bar IG6 produced the lowest glass-surface temperature in the edge-of-glass region.

R-value Performance

The overall R-value of a window is dependent on the type of spacer bar, glazing, and in particular, the thermal properties of the frame material. However, even with non-conductive frame materials, poor design may reduce the thermal performance of the window.

In general, wood has a high thermal resistance and therefore, the FR1 specimens had the

Dr. A.H. Elmahdy is a principal research officer in the Building Envelope and Structure Program of the National Research Council of Canada's Institute for Research in Construction in Ottawa.

best overall R-value, irrespective of which spacer bar was used. The only exceptions were spacer bars IG4 and IG6, where the R-values for FR2 specimens and FR1 specimens were about the same. The FR1 frames combined with the poorest-performing (with respect to R-value) WET spacer bar (IG6), had an R-value only slightly lower than when it was combined with the best performing WET spacer bar (IG8).

Concluding Notes

Manufacturers can use these results as a benchmark for choosing suitable combinations of spacer bars and frame materials to enhance the performance of windows. The results, however, are specific to the spacer bars and frame specimens tested and cannot be extrapolated to other window configurations without further testing. ☼

Mould and Human Health

Excessive indoor dampness is a public health problem because it can cause the growth of mould that is associated with upper respiratory symptoms such as coughing and wheezing. However, concrete evidence that shows a direct cause/effect relationship between specific moulds and more serious health problems such as asthma or cancer has not been established.

To gain an understanding of the relationship between indoor mould and human illness, a panel of experts from four relevant disciplines was convened by the National Association of Home Builders (NAHB) in the US to review scientific literature on this subject. The review included controlled and uncontrolled studies, case and animal studies, review articles, and unpublished research.

The NHAB panel aimed at answering two basic questions: 1) To what extent, if any – and with what limitations and caveats – does the existing scientific literature provide a reliable and reasonable scientific basis for one to conclude that indoor moulds cause any medically recognized human ailments? 2) What future research might be beneficial to determine the links, if any, between indoor moulds and human health?

Moulds in the Indoor Environment

Studies show that indoor mould spore populations resemble outdoor spore populations. All buildings are naturally seeded with spores from the outdoor environment. The presence of mould indoors does not necessarily indicate the presence of mycotoxins, which are compounds produced by some fungi. Mycotoxins are not volatile, do not evaporate into the air, and do not penetrate through materials used in construction. Exposure to mycotoxins happens by inhalation or ingestion of the actual spores themselves, or when other fungal components or fragments are inhaled, ingested, or otherwise make contact with the skin. Outbreaks of health problems associated with indoor air exposure to mycotoxins are rare.

Currently there are many ways to sample for moulds or mould byproducts within the built environment; however, there are no accepted standards for mould sampling in indoor environments or for analyzing and interpreting the indoor sampling data in terms of human health. The variability in sampling methodologies makes it very difficult to compare the results in the scientific literature.

There is a need for further development of methods of mould detection and identification, and for more studies to validate these detection methods in order to improve and to standardize the interpretation of their results.

Possible Health Effects of Indoor Moulds

Various studies have attempted to link moulds to a variety of symptoms such as fatigue, weakness, nausea, vomiting, headache, eye, nose, or throat irritation, dry cough, dry or itchy skin, dizziness, difficulty concentrating, and depression. Collectively, these complaints have sometimes been referred to as "sick building syndrome."

Moulds can cause human aliments by physically invading and infecting humans with the mycotoxins the moulds produce. Under certain circumstances some may be toxic, others may be allergens that stimulate the human immune system. Exacerbation of certain respiratory conditions has been associated with mould including hypersensitivity pneumonitis, asthma, and allergic rhinitis.

There is no reliable scientific data to support any direct relationship between exposure either to indoor moulds or mycotoxins and any human health condition or illness. The evidence to support a direct causal relationship between mycotoxin exposure from indoor mould and any human health condition has not been established. Attempts to interpret laboratory results in the absence of site-specific information are not reliable. However, no study reviewed was structured to be able to clearly document a direct link between a mould and a health effect.

Respiratory ailments, such as asthma, are reported more frequently in damp buildings due, in part, to high humidity which favours the growth of mites as well as certain moulds. Most studies do support an association between indoor dampness and the occurrence or exacerbation of asthma, allergic rhinitis and various respiratory symptoms.

There is enough evidence to conclude that indoor mould is associated with asthma in individuals who already have developed the condition, but there is no evidence to show that mould is the primary cause of asthma.

The people most susceptible to mould-related infections are those with clinically significant immune system problems.

There are no reliable standards for determining whether there is a specific "dose" of mould or if any component of a fungal organism can be related directly to health effects. There is a continuing need for more study into the relationship between indoor moulds and human ailments. While there appears to be a relationship between indoor moulds and allergic illnesses of the upper and lower respiratory tract, the strength and details of this relationship need to be further defined. Although a causal relationship is suspected, the relationship cannot be distinguished from the involvement of indoor dampness, dust mites, and other factors.

This study may seem to be an esoteric exercise, not unlike the medieval philosopher's ruminations about how many angels can dance on the head of a pin.

However, there is no doubt that moulds are a serious concern and can have an impact on human health. While there may not be any direct evidence to be able to pinpoint a specific health effect with a single mould species, the presence of large quantities of mould will have some impact on health.

The presence of mould is also associated with high humidity and moisture conditions, so if there is very little moisture, there will not be much mould. At the same time, moisture in the building will lead to rot and deterioration of the building, so if the mould won't get you, the rot will!

What building professionals need to remember is that mould will grow where there is moisture, warmth and organic material. Addressing the source of moisture, and doing proper moisture management will deal with moisture induced deterioration and also the mould that could have an impact on occupant health.

Although there may be times when specific mould species need to be identified, in most cases this is not necessary. While we cannot pinpoint a specific effect on health to a specific species of mould, we know that high concentrations of mould will have some impact on health, as well as on the durability of the building itself. ☼

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